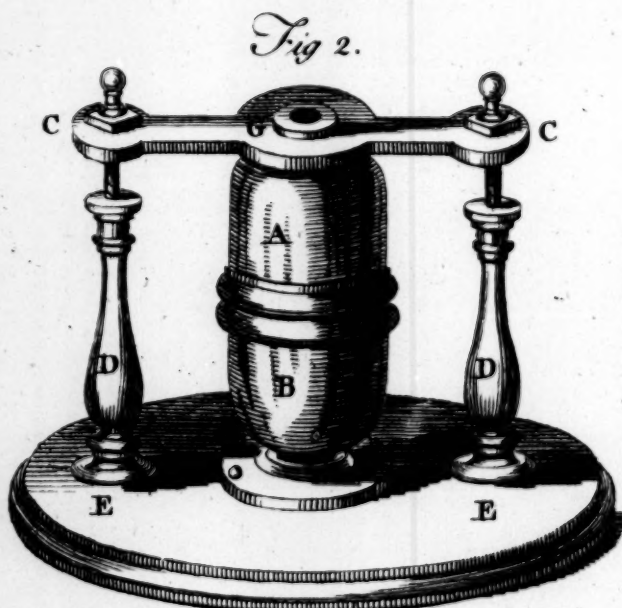
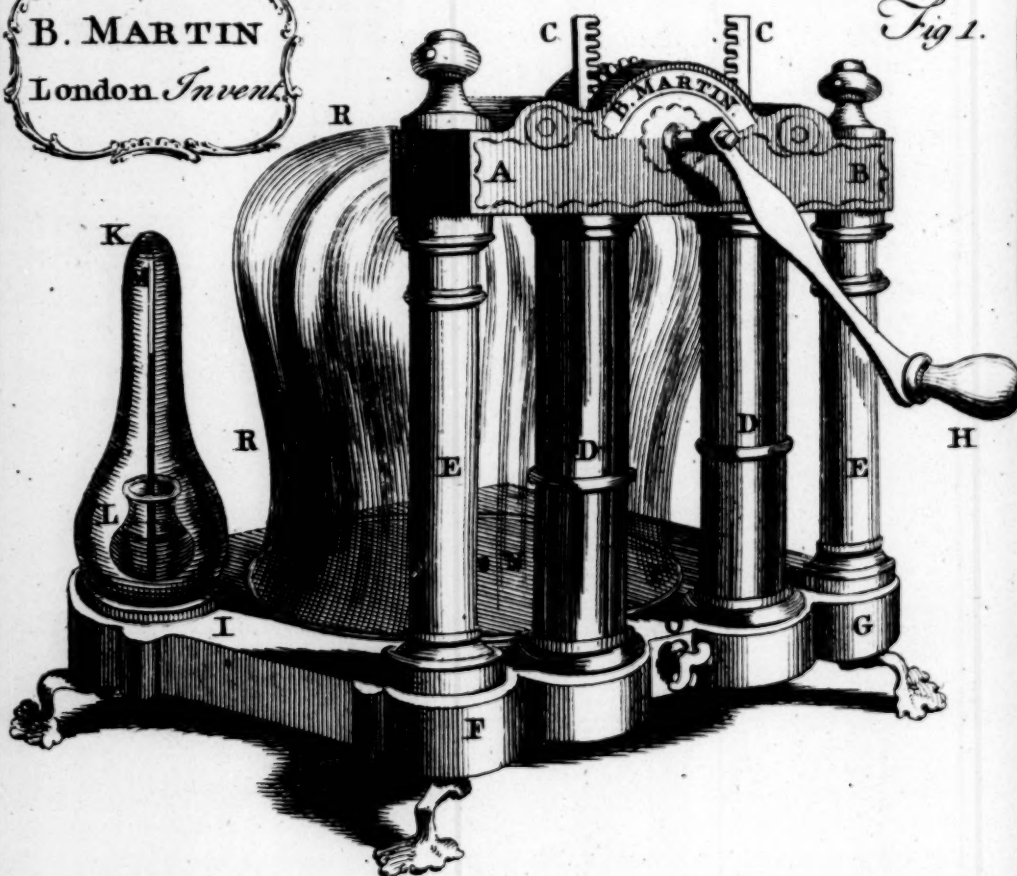


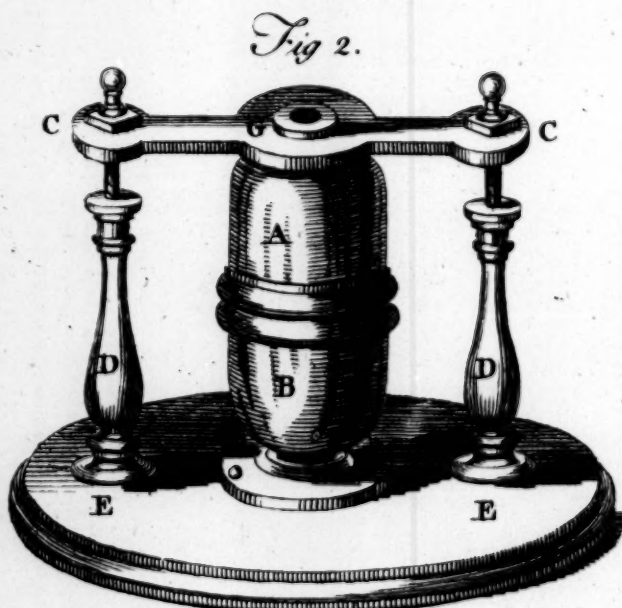
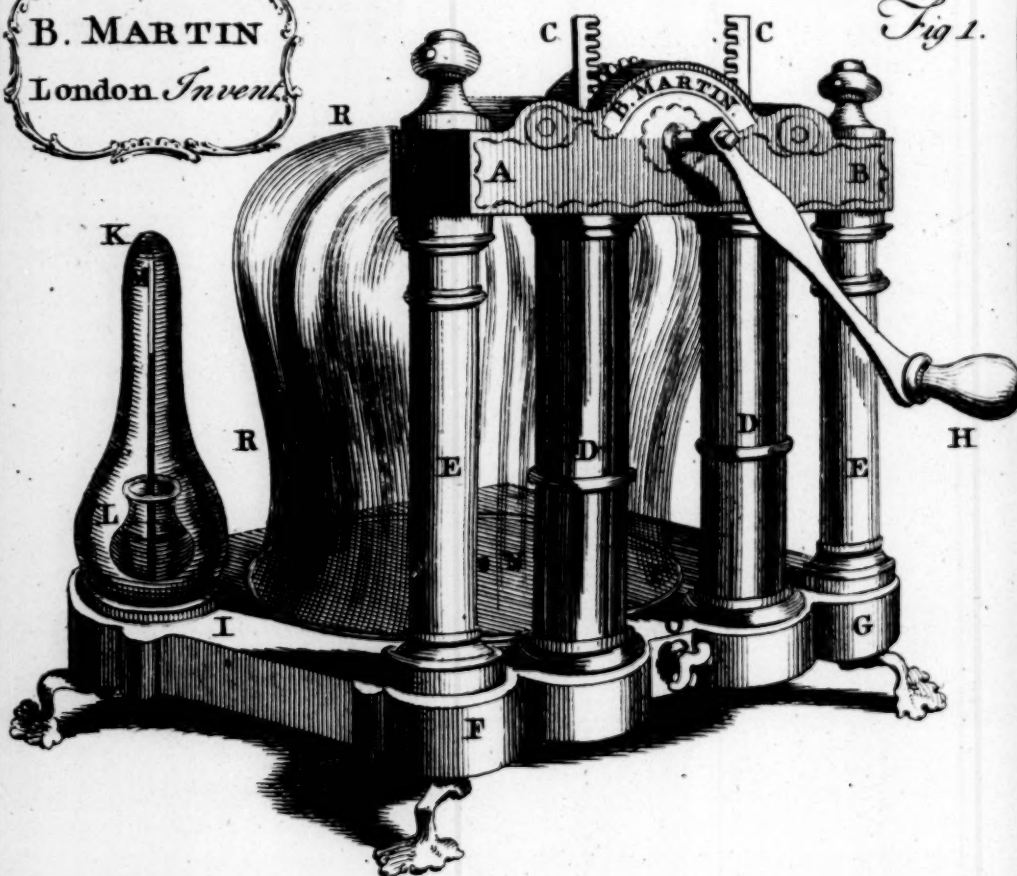
A New Portable AIR-PUMP, and Condensing ENGINE.

B. MARTIN
London Invent.



A New Portable AIR-PUMP, and Condensing ENGINE.

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THE
DESCRIPTION and Use
 OF A
 NEW, PORTABLE, TABLE
AIR-PUMP
 AND
CONDENSING ENGINE.

With a Select VARIETY of
CAPITAL EXPERIMENTS,

Which, together with the different Parts of the
APPARATUS and GLASSES,

Are Illustrated by upwards of FORTY
COPPER-PLATE FIGURES.

By BENJAMIN MARTIN.

⁵⁺
 L O N D O N:

Printed and Sold by the AUTHOR in *Fleet-Street*.
 M DCC LXVI.

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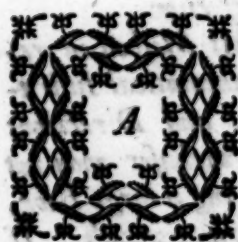
By BENJAMIN MARTIN.

L O N D O N :

Printed and sold by the Author in Fleet-Street.

MDCCLXXI.

P R E F A C E.



S the AIR-PUMP here described and recommended, has for many Years past been made and sold by the Trade, and in very great Numbers lately, I thought it might be deemed rather prudent than presumptuous to let the Public know to whom they may think themselves indebted (if they please) for the same; especially as every one must allow that if I do not this Piece of Justice to myself, I must never expect it from the Ingenuity of those who make and vend them.

Nor will the generous and ingenuous Part of the Public be displeased to be informed where they can bestow their Favours in the most reasonable and grateful Manner, as nothing is more eligible and desirable to Minds benevolent and liberal, than to regulate their Actions by the golden Rule of Rectitude, viz. by doing to others as they would be done by.

The next Motive to my writing this Tract, is to accommodate my Customers and others, with a general Idea of the Apparatus that is necessary for the principal Experiments upon the Pump, and also a Detail of those Experiments and the Manner of performing them. This I am induced to do by the constant Solitude and Enquiry after something of this Sort, by every Gentleman and Lady who buys a Pump. I hope I have hereby satisfied their Request, and gratified their Curiosity, as far as it could be done in two Copper-Plates, filled with Figures of the Particulars of the several Parts of the Apparatus and Experiments; by which Gentlemen will be able to judge and determine, what Part thereof they should like to have with the Pump:

For the above Reasons I have drawn up a Description of the Nature of BAROMETERS, THERMOMETERS, and HYGROMETERS, which I have annexed to this, as they are all related to the same common Subject, the AIR; especially as Gentlemen now begin to be better acquainted with

with the great Usefulness of those Instruments in the most important Affairs of Health, Business, and the general Occurrences of Life; and at the same Time, would be glad to be acquainted with the best Construtions of each, and the Manner of using them in the greatest Perfection.

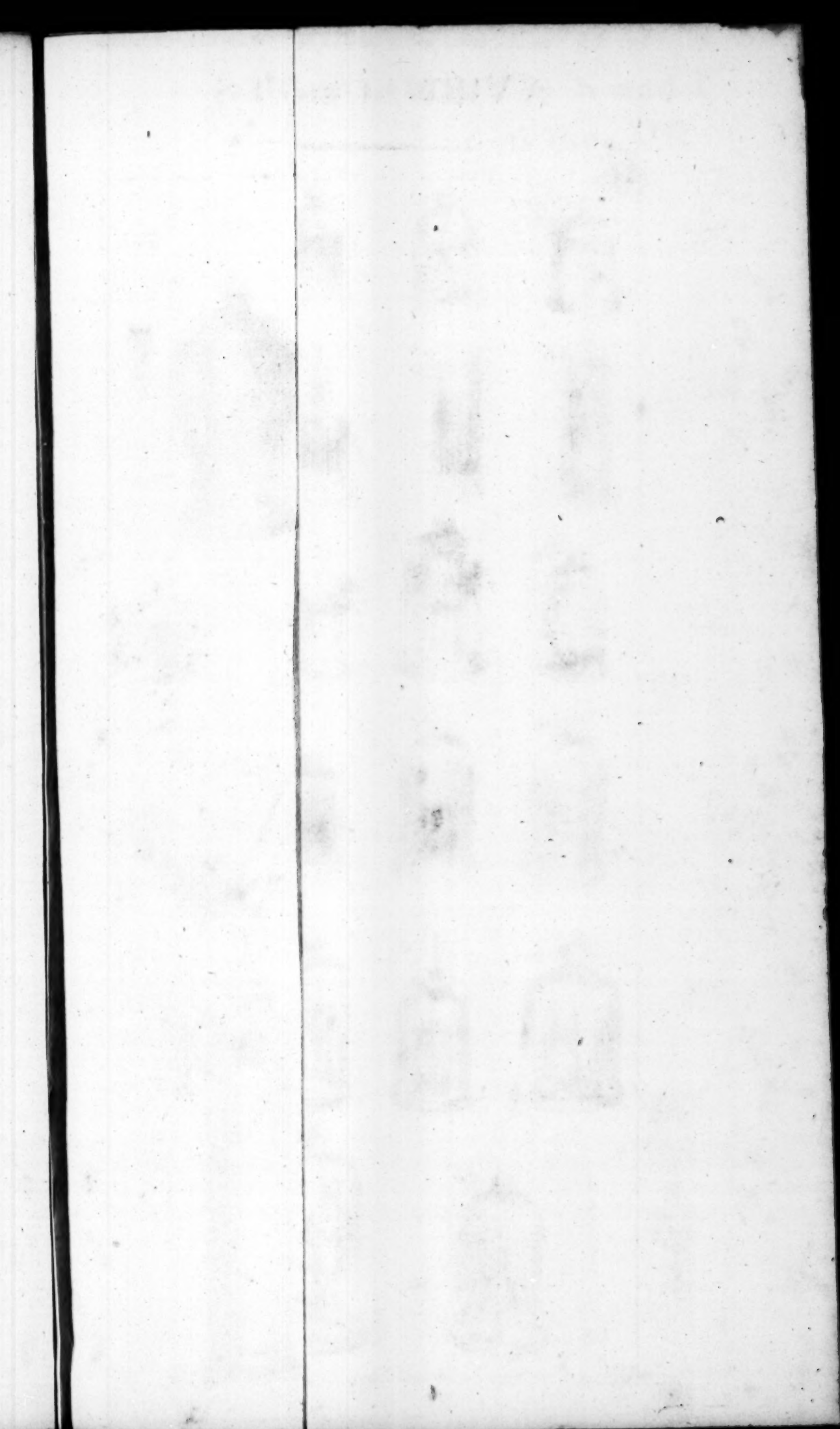
Indeed I find it necessary to pursue this Method in regard to all other Philosophical and Mathematical Instruments, viz. to give printed Descriptions and Directions for the use of the Instrument, that the Purchaser may not be under the disagreeable Necessity of procuring a large Book, or general Treatise for that particular Information only. If by this Means I can facilitate the practical Use of these Instruments, I make no doubt but it will be as acceptable a Service to the Public, as my other Endeavours have proved of making their respective THEORIES much easier to be apprehended, and attainable in far less Time than usual heretofore.

This being the Case, I am not without some Hopes of thereby answering one other great End, viz. to encourage a more general Study of these sublime and important Subjects of Natural Knowledge, which dictate true Notions and just Sentiments of the original and adorable Author, and tend to elevate the rational Mind above the low Pursuits of sensual Amusements, and the little Dignity that can accrue to human Nature from all the Documents of a Play or a Romance. False Taste, and Pedantry should be banished to the Climes of Superstition and Despotism; and genuine Erudition sought for from the BIBLE of NATURE only in this Newtonian Age.

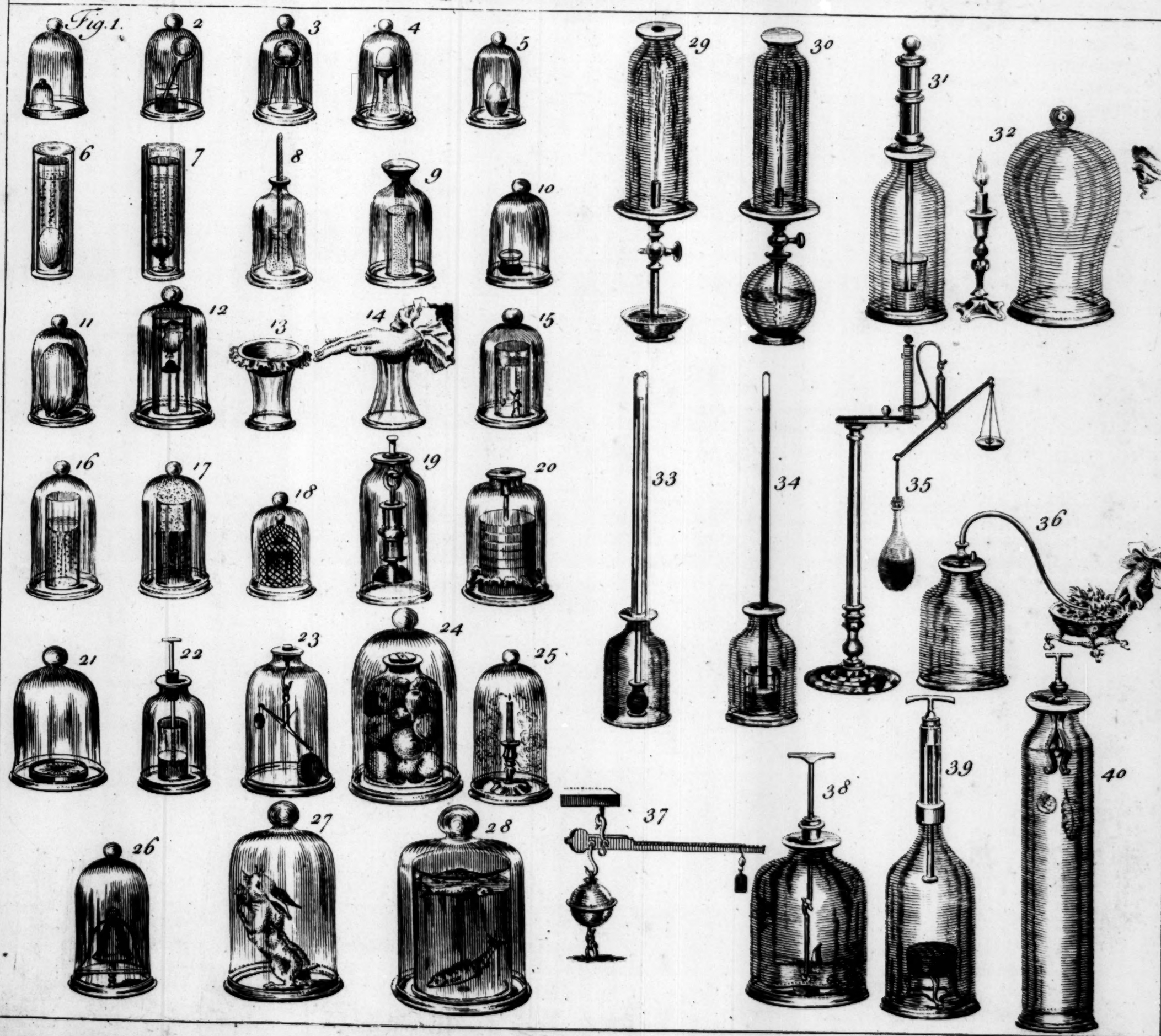


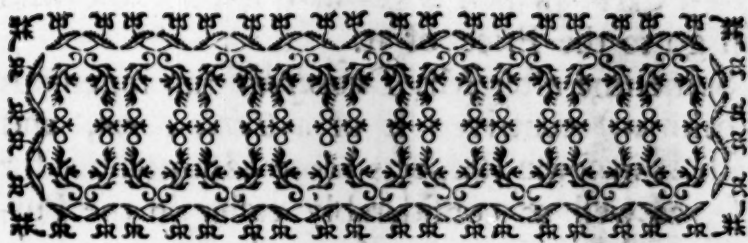
N. B. The Reader is desired to make the following Additions and Corrections, viz.

Page 14, after *Experiment 14*, write *Fig. 7*: Page 28, line 1, for *Fig. 17*, write *Fig. 27*. Ib. after *Experiment 44*, add *Fig. 28*. Page 30, in *Experiment 48*, for *Spring* read *Syringe*.

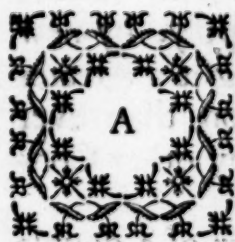


A VIEW of the APPARATUS and Principal EXPERIMENTS upon the AIR-PUMP.





The DESCRIPTION of a New constructed Portable AIR-PUMP, and condensing ENGINE.



AS the Nature and Properties of the AIR make so considerable a Part of the modern PHILOSOPHY, the Invention of a Machine by which they are demonstrated, and made the Subject of our Senses, could not fail of being received with great Admiration and Pleasure, and of being esteemed the greatest Acquisition to the Science.

This MACHINE, while in the Hands of its Inventor, OTTO GUERICKE, a Magistrate of MAGDEBURG, was but of a rude and imperfect form; and was rendered some Time after much more compleat and useful by our Country-man, the honourable Mr. BOYLE. But still, while it was the *Machina Boyleana*, it was far short of that Perfection which its Structure was capable of, and having undergone several Improvements by Dr. HOOKE, Mr. PAPPIN, and other celebrated Philosophers, it received at last an elegant and magnificent Form from the ingenious Mr. HAUKEBEE, and called the *Standing*

B

AIR-

2 *The DESCRIPTION and USE*

AIR-PUMP, which is yet in Use for those who will go to the Price of it.

Sometime after Mr. *Davenport* (an ingenious Workman) contrived it of a *Table Form*, and made it in some Respects more commodious for Use, as well as considerably easier in the Purchase. And for many Years they were made and sold in this Form, and under the Title of *Davenport's Table AIR-PUMP*.

Having many Years used the Air-Pump in both the fore-mentioned Forms, Experience soon convinced me there yet remained many Imperfections and Deficiencies, both in the Structure, and Circumstances of the Pump. These I endeavoured to rectify, and supply, by new modelling of the Form, and giving it a greater Degree of Simplicity and Perfection than ever it had before, or could have in any other Construction.

The Simplicity of this *New Form* of a double barrelled Pump, is manifestly the greatest that can be, because it contains nothing more than the *Head* or Frame of the two Barrels; and the *Basis*, or Bottom on which the Receivers are placed; and that it cannot have a less Number of Parts than these two, is self-evident.

Then as to its *greater Perfection*, no one I presume will dispute it, who considers that all the *Ventages*, or Passages for the Air to go from the Receiver, Gage, &c. to the Barrels, are here in *solid Brass*; in all preceding Forms, they consisted of long *slender Copper Pipes*, which, from their own Nature, must be defective, and liable to be faulty, and are always found to be so by Experience. But, in this New Structure, as all these Passages for Air are drilled through
the

the thick solid Substance of the Brass, it is impossible they should *leake*, or be otherwise than *Air-tight*; and therefore can give no Trouble in working it, nor leave any Air behind that can be drawn out by *this Method and Kind of Exhaustion*.

And it is an Observation that never fails, viz. *That any Machine the more Simple it is, it is always in Proportion so much the more Perfect and Natural*; for Nature is never redundant, but frugally and wisely contrives every Thing with so many Parts (and no more) that are necessary to answer the End compleatly. And the less unnecessary Apparatus and Parts there are in the Structure, the easier will be the Purchase of Course, and the more it must redound to the public Good in the Advancement of the Sciences.

This Form of the AIR-PUMP with its Gage, and a large Receiver upon the Plate, are shewn in the first Figure of the Plate in Front. In which, A B is the *Head* of the *Pump* or Frame containing the Wheel, by which the two Pistons C C, are moved alternately up and down in the Barrels D D, by Means of the Handle or Winch H. The two Pillars E E support the Head, and allow of its being screwed very fast down upon the Barrels D D, which is necessary to keep them very close upon the Leathers at the Bottom, that no Air may get in.

The BASIS, or Bed of the Pump is denoted by I F G, and is a thick Piece of Mahogany, with a large circular Plate of Brass P P sunk into the Middle Part to be level with the Surface thereof. This Plate is continued on one Part to the Front of the Pump, where at O a Hole

4 *The DESCRIPTION and Use*

or Perforation is made to the Center N of the Plate, for the Air to go out and in through it, by turning the Cock or Screw which is seen at O.

In the Corner or Angle of the Bed at I, is fixed another small round Plate of Brass, upon which is placed the Gage, which is a Receiver I K put over a small Basen of Quicksilver L, in which is inverted a short Tube M, filled with the same Fluid; from this Plate to the large one there is a Perforation also through solid Brass, and consequently as the Receiver I K communicates with the large Receiver R R upon the large Plate P P, when the Pump is worked, and the Air is exhausted from those Receivers, it will be shewn by the Descent of the Mercury in the Tube M.

How the Air is exhausted, or the *Vacuum* made, may be thus easily understood. When the Wheel in the Head is turned by the Handle H, it must necessarily move one Piston up, and the other down, in their respective Barrels, at the same Time. And since each Barrel stands upon a round Piece of Brass (with a Leather between) in which there is a *Valve* opening upwards to let the Air come out of the Receiver into the Barrel, it must follow that when the Piston is raised by the Winch, the Column of Air in the Barrel is thereby lifted up, or off from the Valve at the Bottom; by which Means the Spring of the Air in the Receiver will cause it to issue through the Valve into the Barrel, that an Equilibrium may be preserved in the Air filling the Receiver and Barrel.

As the same Sort of Valve opening upwards is also screwed into the central Part of each Piston,
and

and therefore in the Ascent of the Piston, this Valve is kept close down by the Pressure of the external Air or Atmosphere, it must necessarily lift the said Air off from the Bottom-Valve in the Barrel, as was said before, and consequently while each Piston rises, the Air is rushing into the Barrel; whence, as they rise alternately, there is a constant Evacuation of Air from the Receiver.

In the Descent of the Piston, it will compress the Air below, 'till it has a Spring greater than that of the outward Air; after which the internal Air will raise the Valve of the Piston, and make its Escape into the Atmosphere; and hence by the alternate Descent of the Pistons, the Barrels will constantly be discharging the Air with which they are filled from the Receiver.

Hence it will follow that at each Stroke of the *Embolus* or Piston, a *Quantity of Air equal to the Capacity of the Barrel* (viz. that *Part between the Sucker and the Bottom*) *will be extracted*. But it will not follow that because the Air in the Receiver is diminished by every Stroke, *therefore it may at last be all exhausted*. This may seem a *Paradox*, but it is yet no *Mistake*, as I have made appear by Calculation in my *Philosophica Britannica*.

But to illustrate this Matter by Example; suppose the Capacity of the Barrel equal to that of the Receiver, then by the first Stroke just half the Air at first in the Receiver will rush into the Barrel, and be exhausted; and by the second Stroke, half the Remainder will be drawn out, and so on. Therefore at each Stroke the Air drawn out will be to the Quantity of Air in
the

6 *The DESCRIPTION and USE*

the Receiver immediately before that Stroke, as 1 to 2.

Again, suppose the Capacity of the Receiver be to that of the Barrel as 2 to 1, then upon the first Elevation of the Piston, the Air expanding itself into the Barrel, will possess a Space $\frac{2}{3}$ Part greater than before, therefore one $\frac{1}{3}$ Part of the Air in the Receiver will be exhausted at each successive Stroke of the Pump. Or the exhausted Air will be to that immediately before in the Receiver, as 1 to 3. And by reasoning in this Manner for other Proportions of the Receiver and Barrel, we shall find this to be a general Rule, viz. *The Air exhausted by any Stroke, is to the Air in the Receiver immediately before that Stroke, as the Capacity of the Barrel to the Capacity of the Barrel and that of the Receiver taken together.*

Of the CONDENSING ENGINE.

This Machine for *Condensing Air* consists usually of two hollow Cylinders of Brass A B, made very strong, and put together in the Middle with a Leather, to make them Air-tight. These are compressed together in a proper Frame, viz. a strong Transom or Piece of Wood CC, with a Hole in the Middle to go over the Neck G of the Upper Cylinder, and by two Screws at C C, is made to bear with very great Force upon it to act against the Spring of the Air condensed within. The whole is supported by two strong Pillars DD, firmly fixed in the Base or Foot E E. See Fig. 2 in the *Frontispiece*.

The Air is condensed by injecting an additional Quantity to that which is in the Engine
al-

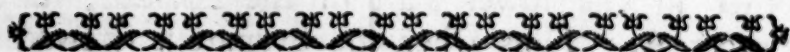
already, by Means of the Syringe A B C (Fig. 3.). To this End it is constructed with two Valves both which open downwards, viz. one at C, in the Bottom of the Barrel B C, and the other in the lower Part of the *Embolus*, or Forcer A. Thus when the Syringe is screwed on to the Neck G of the Condenser, and the Forcer A is raised up, the common Air above will rush through its Valve-part, into the Barrel below, which in the Descent of the *Embolus* is forced into the Cylinders, and condenses the Air which was there before, of Course; and by repeating this Operation, it is condensed still more and more, to any proposed Degree.

There are different Ways of making a *Gage* to measure the Degree of Condensation; but they all do it by compressing a given Quantity of Air into a *less Space* by Means of Quicksilver in a Glass Tube communicating with the Condenser, and properly graduated. Thus when the Air of the Gage is forced into just half the Space it first took up, it indicates there is *one Atmosphere* injected, or that the Air is *twice as dense as the common Air*. If the Air of the Gage be compressed into $\frac{1}{3}$ Part of its original Space or Length of Tube, it shews the Air is three Times as dense as the natural Air. And thus you proceed to throw in 4, 5, or 6 Atmospheres, if the Conderfer be strong enough to contain such very elastic Air.

For some Experiments the Body of the Condenser A B, is an *entire Glass Cylinder*, but very strong. Thus much may suffice for an Account of the Structure, Rationale, and Operation of the AIR-PUMP and CONDENSER. We might next have described the various *Apparatus* used in Experiments of the Pump, but a Knowledge
of

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of these Things, and their Use, are much better obtained by *Inspection*, than by any tedious *verbal Description*.



A select VARIETY of the most curious and instructive EXPERIMENTS upon the AIR-PUMP, with their Uses in Natural PHILOSOPHY.

 E now proceed to explain the Nature and wonderful Properties of the Air by a select Variety of the principal and most important Experiments on the AIR-PUMP.

• EXPERIMENT I. *Fig. in Frontispiece.*

Let a Glass Receiver be placed on the Plate of the Pump, and by exhausting the Air gradually, you will perceive at every Stroke, the Rim of the Glass sink deeper into the moistened Leather, and when you have exhausted all the Air (which can produce any sensible Effect) you will find the Recipient fixed very fast upon the Plate of the Pump by *the Pressure of the external Air*, which is hereby most evidently proved. Note, you let the Air into the Receiver again by turning the Cock at O.

• EXPERIMENT II. *Fig. I.*

Lest any one should imagine the Glass is fixed upon the Plate by any Power or Agent within the same (drawing it down by *Suction*, as was used

used to be asserted formerly, through the Hole in the Plate, let a small Glass be placed on one Side of the Hole, and covered with a larger; then upon exhausting the Air from the large Receiver, the Air will constantly throw itself out of the small one by its Spring, so that both will become exhausted together; then, upon letting the Air into the large Receiver, it will not have Time to get under the small one, but will instantly fall upon it, and *by its Weight* fix it as firmly to the Plate of the Pump, as before; and it will be rather more evident by its *sinking into the Leather*, upon letting the Air into the large Receiver. N. B. The small Glass, when exhausted, is as free to move as before, 'till the Air comes in again and fixes it down.

EXPERIMENT III.

Let a brass Ring and Socket be cemented upon the Top of a small Recipient, placed in either of the aforesaid Ways upon the Plate of the Pump, and when it is thoroughly exhausted, let the End of a Ballance (upon a proper Stand) be applied to it, with Weights put into the Scale at the other End till there be enough to separate the Glass from the Pump; and it will appear *that there will be nearly so many Times 15lb, as there are square Inches in the Area of the Orifice of the Glass. Whence the Air's Pressure on a circular Inch will be about 12lb.*

• EXPERIMENT IV. Fig. 2.

The Manner in which the Air is expelled from the Recipient by the *Spring or elastic Force between its Particles* is thus made evident. Let a Glass Bubble, with a long Neck, be placed with

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the Neck downwards in a small Jar of Water, upon the Plate of the Pump, and cover the same with a Receiver; then upon exhausting, you will observe that as the Air in the large Receiver is diminished in Quantity by the Stroke of each Piston, so its Spring being lessened, the greater Spring of the included Air in the Bubble will exert itself upon the Air in the Neck, and drive it in a very visible Manner through the Water in the Jar into the large Recipient; by which Means there will be a constant Equality between the Spring of the Air in the Bubble and that in the Recipient, 'till both become exhausted.

• EXPERIMENT V.

The Receiver and Bubble being thus exhausted, if you turn the Cock to let in the Air, you will perceive the Effect of its Pressure upon the Water in forcing it with great Rapidity to rise in the Neck and Bulb of the Glass, 'till at Length, when the Air has its full Force, the Water will be seen to fill the Bubble all but a small Part upon the Top, which will be filled with the Air that could not be exhausted; *hence the Quantity of Air exhausted is to the Remainder, as the whole Bubble and its Neck is to the small Pittance of Air now at the Crown or Top.*

• EXPERIMENT VI.

The Bubble being thus almost filled with Water, if it be taken out of the Jar, and held with its Neck downwards, *the Water will run but a very little out*; for the Weight of the Water in the Bubble (in a Cylinder equal to the Cavity of the Neck) and the Spring of the internal Air is equal

equal to the Pressure upwards of the external Air; and an Equilibrium thus produced, prevents any more Water from descending out of the Bubble.

• EXPERIMENT VII. *Fig. 3.*

But when the Bubble thus filled with Water, and a small Quantity of Air, is placed upon the Top of an empty Jar, and covered with a Recipient, as soon as you begin to exhaust, so soon you see the Water begin to drop from the Neck of the Bulb, and the Air to expand upon the Crown of it. For when the Spring of the Air, which acts against the Water and included Air, is lessened, the Water will in Part descend, since the Force of the Air and Water together in the Bubble must ever be equal to the Spring of the Air in the Receiver. As this is therefore constantly lessening, so the Water must keep constantly running out of the Bulb, and the Air in it, of Course, will be as constantly expanding, 'till at Length all the Water is run out, and the Spring of the Air in the Bulb, and the Recipient becomes equal, or the same.

• EXPERIMENT VIII. *Fig. 4.*

In the great End of an Egg there is a small Quantity of Air always included, like that upon the Water in the Bubble; if then a Hole be made at the little End, and the Egg be placed upon an open Glass with the small End downwards, and then the Whole covered with the Recipient, you will see, upon exhausting the Air, the Effect of the *Expansion of the Air included in the upper or great End of the Egg, in gradually expelling the White first, and then the Yolk of the Egg through the Hole into the Glass.*

• EXPERIMENT IX. *Fig. 5.*

This Air at the *great End of the Egg* is included between the Shell and *Putamen*, or Skin of the Egg, as will be evident by making the Hole at the little End larger (*viz.* near an Inch diameter) and placing the Egg upright upon the great End, and covering the same with a small Receiver, exhaust the Air, and you will soon observe the Skin of the Egg to be puffed up, and constantly keep rising through the Body of the Egg, 'till at last you see it rise through the Hole itself, and oftentimes so far above the Hole as to make good the deficient Part of the Shell, and so to restore the compleat Form of the Egg.

• EXPERIMENT X.

The Skin of the Egg thus extruded and expanded in the exhausted Receiver, will, upon letting in the Air, be instantly reduced to its first Situation, and appear as a Lining to the Shell, or rather as a *Dura Mater* to the Contents of the Egg. Hence a Reason is deduced for *breaking a boiled Egg at the great End*, *viz.* because there the Shell is always disengaged from the Skin, and may be taken off with Ease, and without breaking the White, which lies at a Distance under it, by reason of the Expansion of the included Air in boiling.

N. B. This Air in the great End of the Egg is the *Medium* which Nature uses for generating or bringing to Perfection the *embrio-Fowl*, by the constant Motion thereof produced by the uninterrupted Warmth of the Hen sitting upon the same. Therefore, if a small
Hole

Hole were made in the great End of an Egg, the Air would escape, and *no Chick could ever be produced from the Treadle of the Egg.*

• EXPERIMENT XI. *Fig. 6.*

If an Egg be placed at the Bottom of a tall Jar of Water, and then covered with the Receiver; upon exhausting the Air, there will appear several *Jets* or fine Streams of Air rising through the Water from several Parts of the Egg; and as a Vacuum approaches, the Air will escape out of the Pores all over the Surface of the Egg, and stand in little pearl-like Bubbles upon the same. The Egg will also be expanded in Bulk by the internal Air, so that it will be rendered almost as light as the Water, and be raised on one End; and sometimes be made lighter than the Water, and rise to the Top, though this is not a very common Case. Also the Expansion of the internal Air will sometimes crack the Shell, though this but rarely happens. Note, these Experiments succeed best with large and new-laid Eggs.

• EXPERIMENT XII.

Upon letting the Air into the Receiver, the Jets all ~~cease~~, and the pearly Globules of Air re-enter their Pores, and totally disappear. The Egg, too, is plainly seen to contract its Dimensions, to become heavier, and to rest on the Side. But in lieu of the Air, which has made its Escape in the Jets, the Pores or Parts deserted by it are filled with Water by the returning Pressure of the Atmosphere upon that in the Jar.

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• EXPERIMENT XIII.

The Air-bubble destined for the Production of the Chick is therefore not that which rises in Jets from the great End of the Egg, for if that could transpire through the Pores of the Shell, it would fly off, and be lost; but this is not the Case, for if a Hole be made at the little End of the Egg of the last Experiment, and it be placed on a Glass covered with a Receiver (as in Experiment VIII) it will appear upon exhausting, that the Contents of the Egg will be protruded in the same Manner as before, and consequently from the same Cause, viz. *the included Bubble of Air in the great End.*

N. B. By these and such like Experiments on Eggs, it appears they are previous to the Particles of Air, which by their constant Action on the Contents of the Egg, tend to produce an *Alteration, Separation*, and, at length, *Putrefaction* (or *Addleness*) in the Egg; which therefore may in a great Measure be prevented by *gluing up the Pores with hard Varnish, Ising-glass, Glue, &c.* and thus prepared, it has been said *they will keep through an East-India Voyage.*

• EXPERIMENT XIV. *Fig. 7.*

If a shrivelled Apple be put upon a sharp-pointed brass Wire, fixed in a heavy Base or Foot to carry the Apple to the Bottom of the Jar filled with Water, the same Streams of Air will be seen to arise from the Pores of the Apple upon exhausting the Receiver, as appeared before from the Egg, but vastly more numerous. The Bulk of the Apple will also be encreased, and the Wrinkles all disappear; so that it will
look

look near as smooth and fair as when first gathered. As long as the Apple continues in *Vacuo*, so long will the Jets or Streams of Air continue to ascend. But turn the Cock, and let in the Air, and immediately the Jets of Air disappear, and the pearly Bubbles all over the Surface creep again into their respective Pores; the Apple sensibly shrinks in, and becomes withered as at first.

Upon the Return of the Air into the Receiver, it falls upon the Water, and compresses it into the Pores of the Apple deserted by the Air, and which becomes evident in *making the Surface of the Apple look spotted, like a Face soon after the Small-Pox.*

• EXPERIMENT XV.

Tie a Twig with green Leaves, and Stalks of Flowers, to the brass Wire on the Foot, and sink them to the Bottom of the Jar of Water, which cover with a Recipient, and exhaust the Air; then you will have the pleasing View of the Air issuing out of all the Pores of the Leaves and Body of the Twig, and from the Stem, Leaves, and every other Part of the Flower, in a most beautiful Manner. But upon letting in the Air, the active Scence is instantly closed, and the struggling bustling Bubbles of Air are immediately hushed, and made to retreat within their invisible Cells.

• EXPERIMENT XVI.

It is well known that a Plant or Vegetable of any Kind is an *organized Body*, that is, constructed with proper *Vessels* or Parts to imbibe and circulate the Juices, Air, &c. necessary for the

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the Support of *Vegetable Life*. It is further evident that those Vessels destined for the Circulation of Air, have a most wonderful Structure and Mechanism for that Purpose, most of which is discoverable by the Microscope, and that they are always repleat with Air is evident by Experiment. For take a Piece of the Stem or Body of a small Tree or Bough, and cut one End transversely with a very sharp Pen-knife, 'till the Pores or Orifices of the longitudinal Vessels are laid quite open, then fix it at the other End on the pointed brass Wire, and sink it to the Bottom of the Jar of Water; when this is covered, and the Air of the Receiver exhausted, you will see an amazing Quantity of Air pour out of these Vessels, and rise in a Column through the Water as large as the Wood itself, and this rising Column will continue as long as there is a Vacuum in the Receiver; but it will cease on letting in the Air, which will then force the Water into the Vessels now emptied of Air, which will make the Piece of Wood sensibly heavier than at first.

• EXPERIMENT XVII. *Fig. 8.*

But for a further Proof and Illustration of this Doctrine of the Air's Circulation in Vegetables, let a Piece of Wood be taken eight or ten Inches long, and each End cut as before, to lay the Vessels open; then this Piece of Wood being cemented about the Middle into the Socket or Collar of a Plate, is put through the Top of an open Receiver, with the lower End immersed into a Glass of Water; and the Whole being secured every where with wet Leathers, you will observe upon exhausting
the

the Receiver, a very large Quantity of Air will rush through the Wood into the Receiver, and fill the Water with Bubbles. When the Vacuum is pretty far advanced, you may cease working the Pump, and the Air will continue to come in through the Vessels of the Wood; if you put your Thumb upon the Top of the Wood, you prevent the Air coming in; upon taking your Thumb off, you will see it rush through the Wood and Water again as before. And this entertaining Operation may be repeated as often as you please. But as last, letting the Air in by the Cock, the Torrent through the Wood ceases, as the Pressure within becomes equal to that of the external Air.

• EXPERIMENT XVIII. *Fig. 9.*

The great Porosity or vascular Texture of Wood may be otherwise shewn thus; let a Piece of Willow Wood about an Inch long be cemented into the Socket of another Piece of Box, Brass, &c. made hollow on the Top like a little Basin, which you fill nearly full with Mercury, and place it with a wet Leather upon the Top of an open Receiver; then begin to exhaust, and the Pressure of the Atmosphere upon the Quicksilver in the Basin will soon force it through the Capillary Tubes of the Wood in Form of a beautiful *Shower of Mercury*, which will continue, (without further exhausting,) after it has once began, 'till all has passed through, and then the Air follows, and fills the Receiver. Note, unless the Ends of the Piece be very nicely pared with a Pen-knife or Razor, the Experiment cannot well succeed.

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• EXPERIMENT XIX. *Fig. 10.*

Another curious Method of demonstrating the longitudinal Vessels in Wood, is *by injecting the same with Quicksilver*; thus, take a Piece of Wood (Willow is the best) about half an Inch long, and place it at the Bottom of a small Glass, with a springy Piece of Cork, that it may not rise when you pour in Quicksilver to cover it totally; after which put it under a small Receiver, and exhaust the Air very thoroughly; during the Operation the Air contained in the Wood, will be seen to throw itself out of the Pores through the Mercury; and when the Vacuum is made as far as possible, let in the Air, which falling upon the Quicksilver, will force it into all the Pores or Vessels of the Wood, which when taken out, will be quite blue at the Ends with the Mercury injected; if it be split into Pieces, the Mercury gives it the same Hue with-inside in every Piece; if the Piece be weighed before and after Injection, it will appear how much Quicksilver has entered its Substance; if put into Water, it sinks like a Stone.

• EXPERIMENT XX.

There are two Parts in Vegetables that are *not porous, or vascular*, but are just the contrary, being of a *vesicular Texture*, viz. consisting of fine small *Bladders*, which plainly appear in the Microscope. And these are the *Pith*, and the external *Bark*; and though these Substances contain Air, yet they do it not in the common Way, but it seems to be contained in the *little Vesicles* so as not to find an Exit *in Vacuo*. For take a Piece of Cork, and a Piece of the Pith
of

of Elder; and tie them fast to the Brass Stem, and immerse them in the Water of the Jar; then cover the same with a Receiver, and exhaust the Air; during the Operation, you see none of the numerous regular Jets of Air from either the *Cork* or the *Pith*, as before you observed from the Body or Wood of the Plant; indeed, many Bubbles will issue from each Substance, but they are only like what appeared on the *Surface* of the Egg, and of the Pieces of Wood, viz. such Air only as is contained in the Interstices, or *between the Vesicles, Vessels, &c.* and *not that which is in them*. But the Nature, Use, and Design, of these Parts of a Vegetable, though the most obvious, are perhaps the least known of any.

• EXPERIMENT XXI. *Fig. 11.*

A Bladder emptied of Air, and its Neck fast tied, being put under the Receiver; then as the Air is gradually exhausted, the Air in the Bladder will more and more expand, 'till at length, when the Vacuum is far advanced, the Bladder will be stretched to its full Bulk, and look as if full-blown. On letting in the Air again, it reduces the Air in the Bladder to its original Density, and the Bladder itself reassumes its empty Appearance.

• EXPERIMENT XXII. *Fig. 12.*

If a Weight be tied to the Neck of the same Bladder, and then immersed in a Jar of Water and put under the Receiver; as soon as the Pump begins to work, the Bladder begins to expand, and so will continue 'till it becomes so considerable as to raise the Weight connected

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with it to the Top of the Water. When the Air is let in, the Bladder shrinks, and descends to the Bottom.

• EXPERIMENT XXIII. *Fig. 13.*

If a Piece of wet Bladder be fast tied over the large End of the Hand-glass, and the other End placed upon the Plate of the Pump over the Hole. Then, upon extracting the internal Air, the Pressure of the Atmosphere will soon be evident in depressing the Bladder still lower and lower into the Glass, 'till at last its Force exceeds that of Cohesion in the Bladder, and rends it with a prodigious Explosion.

N. B. The Form of the Bladder in its State of Depression, is that of *the Segment of a Sphere.*

• EXPERIMENT. XXIV

A Piece of ground plate Glass, if not too thick, being laid upon the Top of the same Glass, with a wet Leather between, and covered with the Receiver, will, upon exhausting the Air, be broke into many Pieces.

• EXPERIMENT XXV. *Fig 14.*

If the Ball of the Thumb be laid upon the small End of the same Glass, as the Air within is extracted, the *Spring of the Air in the Flesh* will cause a visible Protuberance thereof, which will appear very red by the great Quantity of Blood impelled to that Part; the Hand is fastened upon the Glass by the Pressure of the Air upon it; but you may lift it off, and it will, for some time after, continue to look red,

red, and the Impression of the Glas be felt with some Degree of Pain.

N. B. This Experiment shews the *Nature of CUPPING*, and how the Part of the Body to which the Glas is applied, becomes fitted for *Scarrification*.

• EXPERIMENT XXVI.

Turn the Glas with the broad End upwards, and lay the Middle of the Palm of your Hand upon it, and begin gently to exhaust the Air; then you will both *feel and see the Weight of the Atmosphere press down the Skin and Flesh (upon the Back of the Hand) between the Metacarpal Bones*. This Pressure becomes insupportable soon, but can do no Harm, as you may let in the Air when you please.

By these Experiments it appears, that the Spring of the Air within our Bodies counteracts the Pressure of that without, which is the Reason why neither of them can be sensible when they act together; but that either Force acting alone, will be extremely so.

• EXPERIMENT XXVII. *Fig. 15.*

If Glas Bubbles, Images of Men, &c. with small Holes in them, be filled with Water to make them sink to the Bottom of a Jar of Water, and placed under the Recipient, then, upon exhausting the Air, that in the Body of the Images will expand itself and drive out Part of the Water, which will render them specifically lighter than the Water of the Jar, and of Course, they will rise to the Top. Upon letting in the Air, that in the Bubble and Bodies
of

of the Images will be condensed by the Water forced into them again, and then they gradually descend to the Bottom again.

• EXPERIMENT XXVIII. *Fig. 16.*

If a Jar of clear cold Water be put under the Recipient, and the Air drawn out, there will appear many small Bubbles and Streams of Air to arise out of the Body of the Water, particularly from the lower Parts; by which it appears what a large Quantity of Air is naturally contained in Water. The same Experiment tried with Oil, Spirit, &c. shews they are all impregnated with Air, more or less.

• EXPERIMENT XXIX.

But if hot Water in a Jar be put under the Receiver, and the Air be exhausted, it will soon discover a great Expansion of its contained Air by the Heat, which will appear in Bubbles very numerous, and larger still as the Exhaustion is continued, 'till at length it becomes so very quick and violent as to produce those Agitations which are usually called *the Ebullition or Boiling of the Water*; but this is most considerable towards the Beginning, for as the Air becomes more and more exhausted, the Ebullition is lessened gradually; 'till at last, the Air shews itself in few, but these very large Bubbles or Volumes, which as they agitate the Water but little, so it may now be said to *cease boiling*. And when the Air is let in, all Motion is totally at an End.

By this Experiment we are taught, that the Boiling of Fluids is owing to a violent Rarefaction of the contained Air by Heat; and that a
little

little Heat would produce this Effect were it not for the Pressure of the Atmosphere.

• EXPERIMENT XXX. *Fig. 17.*

If Beer or Ale be put into a tall Jar, and placed under a Receiver, as soon as the Air is in the least Degree extracted, the Air in the Beer will begin to shew itself in rising Streams through all the Body of the Fluid; and as the Vacuum proceeds, those Streams will be more copious and evident in Proportion. But the Beer being a viscid Substance, its Particles will stick about and line the Vehicles of Air in such Manner, that they cannot here break and fly off, as in Water; but they will rise to the Top, and be there accumulated into a *frothy Head*, which will keep encreasing 'till it runs over the Top of the Jar; then upon letting the Air into the Receiver, it quashes the aspiring Head, and reduces it to the Level of the Liquor.

This Experiment affords a remarkable Proof of Sir ISAAC NEWTON's Doctrine, *that Opacity in Bodies chiefly arises from the Largeness of their Pores or Interstices, and that Transparency is owing to their being small*; for the Body of the Beer is very diaphanous, while that of Froth is altogether opake. If the Beer remains long in the Vacuum, and tasted as soon as taken out, it is vapid or *dead*, for want of Air to give it Spirit.

• EXPERIMENT XXXI. *Fig. 18.*

If a thin Glass Bottle, of a square Form, or flat Sides and Bottom, be capped with a Piece of Brass, in which is a small Hole, with a Piece of wetted Bladder tied over it; and then placed
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under a wire Cage in the Recipient, and the Air drawn out, it will at the same Time throw itself out of the square Glass by its Spring, then upon suddenly letting in the Air, it will not have Time to get under the Bladder Valve into the Bottle, but exerting its Force against its flat Sides, will instantly crush it into a thousand Pieces.

• EXPERIMENT XXXII.

Take another of these square Bottles, and close up the Orifice with hard Cement, so that none of its included Air can escape, then having placed it under a Cage and Recipient, begin to exhaust, and proceeding gently, you will find the Spring of the confined Air, will be superior to the Cohesion of the Glass and Spring of the Air in the Receiver together; and, of Course, must burst the Bottle to Shivers.

N. B. In the same Manner you break a full-blown Bladder, with its Neck fast tied.

EXPERIMENT XXXIII. *Fig. 19.*

Take a SYRINGE with a Piston nicely fitted, but without any Perforation or Valve; and having a Weight screwed on to the Bottom sufficient to overcome the Friction of the Piston, and to prevent any Air getting into the Barrel, it is to be suspended by the Ring of the Piston, upon the Wire-hook of a brass Plate, laid on the Top of an open Receiver, and then upon exhausting the Air, you see the Barrel of the Syringe descend by Degrees from the Piston for want of the Spring of Air to keep them together as at first. And when the Air is quite exhausted

exhausted, the Syringe will have descended its whole Length from the Piston; then upon letting in the Air, the Barrel and its Weight will suddenly leap up to the Piston, and be kept firmly together by the Pressure thereof upon each.

EXPERIMENT XXXIV. *Fig. 20.*

A Bladder with a small Quantity of Air in it and its Neck fast tied, is put into a round wooden Box, and upon it are placed several heavy Weights with Holes through the Middle of them, that by a strong Wire fixed in the Brass Plate on the Top of the Receiver, and passing through them, they may be kept very steady and upright. This Apparatus is put under the Receiver, and as the Air is exhausted, the Spring of the Air in the Bladder will shew itself by evidently raising up those heavy Weights which lie upon it; and when the Air is quite exhausted, the Weights are sustained at a sensible Distance from the Bottom of the Box; and gradually sink down again as the Air is let in.

• EXPERIMENT XXXV. *Fig. 21.*

If a *Magnetical* NEEDLE and COMPASS be placed under the Receiver and the Air exhausted, the Magnet applied will attract it just the same *in Vacuo*, as in the Air; and as well through the Glass, as though none were there.

EXPERIMENT XXXVI. *Fig. 22.*

A *Capillary* TUBE of GLASS being properly suspended in the Pipe of a Wire passing through, and moveable up and down in a Collar of Leathers, in a Plate of Brass, upon the Top of an
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open Receiver, is to be raised a little above the Surface of Water in a small Jar; and when the Air is as far extracted as possible, push the Wire down, and immerge the lower End of the Glass Tube in Water, and the Water will be seen to rise in the Tube by Attraction, just in the same Manner and Degree, as in the Air; this will be evident by letting in the Air, which will make no Alteration at all.

EXPERIMENT XXXVII. *Fig. 23.*

If a *Piece* of CORK, and a Piece of any heavy Substance, as BRASS, &c. be nicely equipoised upon a fine Balance, and then put under the Receiver, upon exhausting the Air, you will soon perceive the *Equilibrium* begin to be destroyed, and very soon the Cork will preponderate, or weigh down the Brass.

Hence the true or absolute Weights of Bodies cannot be known or compared but *in Vacuo*, or in an unresisting Medium.

Hence a Pound of Feathers weighed in Air, is absolutely heavier than a Pound of Lead or Brass in the other Scale. The Reason of all which is evident, viz. *the larger Bulk of Cork is more resisted by the Air, than that of Brass so much less*; as appears by letting in the Air, *which immediately restores the Equilibrium.*

EXPERIMENT XXXVIII. *Fig. 24.*

If Fruit of any Sort be put into a proper Glass, with an open Neck, and a Brass Cap and Valve fitted thereto, and cemented upon it, and the Whole placed under the Receiver. Then when the Air is exhausted, and let in again, it will

will fall upon the Bladder Valve, and keep it fast down, and then it may be secured from Air, by sealing it close with Wax. By this Experiment you will find the Difference in keeping choice Fruit *in Vacuo*, and in the Air, and from thence learn how far the *Art of PASTRY* may be improved by the AIR-PUMP.

• EXPERIMENT XXXIX. *Fig. 25.*

If a CANDLE be placed under the Receiver, and the Air be but little diminished by exhausting, the Flame will appear declining, and grow less and fainter, as the Air is further exhausted, 'till at last it becomes quite extinct; and then the Air is so light that the very *Smoke of the Candle* will be seen to descend to the Bottom, and be drawn out with the Air.

Hence appears the *Necessity of Air* for FIRE and FLAME, as containing a Principle or Spirit which is the *Pabulum* thereof.

• EXPERIMENT XL. *Fig. 26.*

If a BELL be placed under the Receiver, adapted to a proper Apparatus, and the Air exhausted, the Sound upon ringing, or striking the Bell, will be scarcely sensible; even the Receiver alone placed over the Bell (without exhaustion) will render the Sound very weak and low.

Hence we learn that SOUND is communicated by PULSES of *elastic AIR* to the *Tympanum* or Drum of the Ear, and there becomes sensible by the Action or Motion of the internal Air upon the *Fibres of the Auditory NERVE*.

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• EXPERIMENT XLI. *Fig. 27.*

AN ANIMAL (as RAT, &c.) being put under the Receiver, when the Air begins to be exhausted, shews Signs of Uneasiness and Pain; as you continue the Operation, the Animal convinces you of encreasing Pain and Agonies, 'till at length it expires in the utmost Convulsions.

• EXPERIMENT XLII.

As the Animal lies prostrate, and apparently dead, upon the Plate of the Pump, yet if you let in the Air in time, or before the Action of the Heart ceases, it will soon discover Signs of *Life*, the Body heaves, the Legs start out, and by-and-by the Animal begins to rear itself up, and to walk or fly about.

By these Experiments it is plain, there is such a Thing as *Temporary DEATH*; and quere, if it be not a Consideration worthy of the *Legislature*, as sometimes a *Temporary Death* may be of more Service, and be more consistent with Justice, than an absolute or real Death.

• EXPERIMENT XLIII.

INSECTS, REPTILES, and other *Animalcules*, will not be killed by the greatest *Vacuum* the Pump can make; and for the most Part, you will find they demonstrate little or no Sensation of Pain; you see them creep and crawl about, but you will find that even *Butterflies*, and *Moths*, cannot fly in a Vacuum of the grosser Air.

• EXPERIMENT XLIV. *Fig. 28.*

If FISHES be placed in a Jar of Water under the Receiver, as you exhaust, you will perceive

perceive the Air to come out of their Mouths in large Bubbles, and their Bodies to extend from the Expansion of the Air in their Bladders, which now becomes involuntary ; and they generally necessitated to rise to the Top of the Water, where they will make many Efforts to descend, but cannot ; they lie for some Time at the Top with their Bellies upwards, and after that seem to recover themselves, and swim about, but not able to descend. If the Bladder breaks, the Fish dies, but scarce ever else. The Fish called the *Loach* will not rise from the Bottom. Upon letting in the Air, they return to their first State, and appear not the worse for what is past.

• EXPERIMENT XLV.

If a Bladder be tied to a Brass Pipe, and then blown nearly full of Air, and screwed into a Bottle upon a Foot, and thus placed under the Receiver ; when you work the Pump you draw the Air out of the Bladder, as well as out of the Recipient, and the Air confined in the Bottle, will, by its Spring, compress the Bladder, 'till at length it has the Appearance of an entire empty Bladder ; then, upon letting in the Air, it will rush through the Pipe, into the Bladder, and expand again gradually to its first Size. This Experiment is to shew the Manner in which the Lungs of Animals are affected, when they are killed and recovered again in the Receiver, and may suffice, to the *tender-hearted*, to convey the intended Ideas, *without torturing the Animal for Amusement.*

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• EXPERIMENT XLVI. *Fig. 29.*

If a tall Glass be exhausted upon the *Transferer*, and then a Pipe screwed on to the Stop-cock, and placed with the lower End in a Basin of Water, you will, upon turning the Cock, see a beautiful *Jet d'Eau* in the exhausted Glass, by the Pressure of the Atmosphere upon the Water in the Basin. This Experiment shews the *Rationale* of raising Water by a Pump for the Piston making a *Vacuum* in the Barrel, the Water will rise in the Pipe below by the Pressure of the Air on its Surface.

• EXPERIMENT XLVII. *Fig. 30.*

If the Glass on the *Transferer* be exhausted, and the Pipe below be screwed into a Bottle, partly filled with Water; then, upon turning the Cock, you will see the same *Jet d'Eau* as before, proceeding now from the *Spring of the Air* confined in the Bottle, which ever produces the same Pressure, and must therefore cause the same Effect, as the *Weight of the Atmosphere*.

EXPERIMENT XLVIII. *Fig. 31.*

To demonstrate still further, the Nature of Pump work, let a *Syringe* with its Pipe be screwed into a Brass Plate, and placed upon the Top of an open Receiver, so that the lower End of the Glass Pipe may descend a little Way into Water of a Glass put upon the Plate of the Pump for that Purpose; then, before you exhaust the Receiver, lift up the Piston of the *Syringe*, and the Water will rise in the Pipe below; but when the Air is exhausted very thoroughly, the Piston raised as before, you

you see no Water rise in the Pipe; the Pressure of Air in the Receiver (as the Cause) being taken away, the Effect must cease, i. e. *no Water can rise in the Pipe of the Syringe or Pump.*

• EXPERIMENT XLIX. *Fig. 32.*

A Candle placed by the Head of a Globulous Receiver, will, when the Air begins to be extracted, appear to have its Rays refracted into various Circles of coloured Light, by a particular Density of Air and Vapours in the Recipient; since before and after that, no Colours are to be seen. By this Experiment we learn, that HALOS *about the Moon*, are owing to a peculiar Mixture and Density of the Air and Vapours through which her Light is refracted.

EXPERIMENT L. *Fig. 33.*

Let a Glass Tube close at one End be filled with Mercury, and inverted into a small Basen of the same Fluid, then will the Mercury in the Tube subside 'till it comes to be of a certain Height, where it remains quiescent: In this State place it upon the Plate of the Pump, put over it an open Recipient, capped upon the Top; and lastly, over the Tube of Mercury put a long Glass Tube about an Inch diameter, which is to be screwed fast into the Brass Cap or Ferril of the Receiver. Then as you begin to exhaust the Air, you will perceive the Mercury begin to descend in the Tube; and as the Air is more and more exhausted, the Quicksilver will sink lower and lower in the Tube, 'till at last a Vacuum being made, its Height above that in the Basen, is but very small.

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By this Experiment it appears that the Mercury in the *Tube* of a BAROMETER is supported by the Pressure of the Air, and consequently *its Altitude is an adequate Measure thereof, when properly corrected.*

EXPERIMENT LI.

The Tube of a Barometer being (in the last Experiment) exhausted of its Mercury and Air, becomes a *Void*, and therefore being immersed in Mercury, it is no Wonder that when you turn the Cock, and let in the Air, you see the Quicksilver rise in the Tube by the increasing Pressure of the Air coming into the Receiver, so that the Air is here shewn by ocular Demonstration *to sustain the Mercury in the Tube at Heights always proportional to its Weight or Pressure.*

EXPERIMENT LII. *Fig. 34.*

If a Tube, open at both Ends, be screwed into a small Bottle of Quicksilver, and covered with the Receiver and long Tube as before; then upon exhausting the Air, the Mercury will begin to rise in the Tube by the Spring of the Air in the Bottle, which becomes greater, and the Mercury rises higher, 'till the Air is as far exhausted as it can be, and then the Height of the Quicksilver in the Tube is the same as that of the two foregoing Experiments, and consequently it is hereby again shewn, *that the Force of the Air's Spring is always equal to that of its Pressure.* Upon letting in the Air, the Mercury subsides to the Bottom.

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EXPERIMENT LIII.

If a Glass Tube about 6 or 7 Inches long, hermetically sealed at one End, be filled with Mercury, and inverted into a small Glass of that Fluid; the Pressure of the Air will prevent its descending from the Top of the Tube. But if in this Circumstance it be placed under the Receiver, and the Air exhausted, you will observe that a considerable Quantity of Air must be drawn out, before the Quicksilver will be seen to descend; for it cannot move while the Spring of the Air is able to support a Column of Mercury to the Height of the Tube; but when that Spring becomes less than the Weight of that short mercurial Column, then it must descend, and continue to do so 'till it is quite subsided, and shews a *Vacuum*.

From this Experiment you see the Reason of the *mercurial GAGE* shewn upon the *PUMP* in the *Frontispiece*.

EXPERIMENT LIV. *Fig. 35.*

If a *Florence FLASK*, properly capped with a Piece of Brass, and a Bladder Valve upon it, be put under the Receiver as the Air becomes exhausted, so it will gradually get out of the Flask from under the Valve, 'till both the Flask and Receiver become evacuated together; then the Air being let in suddenly, will fall upon the Valve, and keep it fast down, so that the Flask will remain exhausted. In this State let it be carefully equipoised upon a fine Balance; and then if you lift up the Valve with a Pin, you will hear the Air rush into the Flask, and see it preponderate by the additional Weight of

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Air

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Air which has entered to fill it. Lastly, by putting Grain-Weights into the Scale, 'till the Equilibrium be restored, *you find the Weight of that Bottle of Air.*

In this Manner we find that a *Pint* of Air weighs eight *Grains*; a *Gallon* weighs one *Drachm four Grains*; and a *BUSHEL* of AIR a little more than an *OUNCE, Troy.*

• EXPERIMENT LV. *Fig. 36.*

An Air-Pipe, with its Stopcock and Plate, being made Air-tight, and then placed upon the Top of an open Receiver, the Air is exhausted as usual, but is let in again through the long Air-pipe, whose End is placed in the Middle of a *burning Charcoal Fire*, and thus the Receiver is filled with *burnt, or adust Air.*

Having removed the Pipe and Plate, you put a small lighted Wax Candle into the Receiver, and it instantly goes out upon the Top, nor can you make it burn in the adust Air 'till great Part of it be let out by lifting up the Receiver; the Candle then burns but dimly, but will purify the remaining Air by Degrees.

This Experiment shews the Nature of that noxious and deleterious Air, so often found in Mines, and deep Places,—and of the fatal Custom of sitting in a close Room, with a Charcoal Fire, which so far contaminates the Air, as to endanger Life, as we know by too common Experience.

• EXPERIMENT LVI. *Fig. 37.*

If two BRASS HEMISPHERES, properly put together, and screwed into the Hole of the Pump, be exhausted of the internal Air, the
Pressure

Pressure of the external Air will compress them very firmly together, so that a great Force will be required to separate them. But upon turning the Cock, and letting in the Air, they fall asunder of themselves

N. B. If this Experiment be very carefully made, and the Hemispheres applied to a Steel-yard, the Weight to separate them will again shew that it is near 15lb per *square Inch* in the Area.

EXPERIMENT LVII. *Fig. 38.*

A Slip-wire and its Collar of Leathers on a Brass Plate, being put upon the Top of an open Receiver, and within connected to the Trigger of a Gun-lock, fixed to the Plate of the Pump, and ready cocked; then when the Air is exhausted, if you pull up the Wire, and draw the Trigger, the Cock will go down, and the Flint strike the Steel with its usual Force, but now *no Sparks of Fire appear*, as there always do in the Air.

EXPERIMENT LVIII.

If two *Iron BULLETS* be made red hot, and one of them put under the Receiver, and the Air extracted, it becomes immediately obfuscated, and totally loses its Luminosity, whilst the other remaining in the Air continues to glow or shine for a considerable Time. This Experiment is not essentially different from the last, because the *Sparks in striking Fire*, are only very *small Pieces or Spherules of melted, or red-hot Steel*; but cannot in *Vacuo* make that Appearance.

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EXPERIMENT LIX. *Fig. 39.*

Upon the Neck of a tall Receiver, a proper Apparatus is fitted, containing a Chamber or Cavity holding a little GUN-POWDER, with a hollow Slip-wire passing through it, and at the same Time a red-hot Iron is placed upon an Iron Tripod, on the Plate of the Pump directly under the Pipe. Then exhausting the Air as soon as possible, you lift up the Wire, and the Grains of Powder will fall through the hollow Part on the hot Iron, which will only *melt and dissolve* upon its Surface, but not *flash and explode*, as in the Air; hence it appears how far the Air is necessary for Gunpower to have its proper Effect.

EXPERIMENT LX. *Fig. 40.*

A Brass Apparatus adapted to the open Top of a very tall Receiver is contrived to hold, and to let fall together, two Bodies, one very heavy, and the other very light, as a GUINEA, and a fine FEATHER; then, upon extracting the Air, and pushing down the Wire, the two Bodies are let go, and they fall together to the Bottom, exactly in the same Time; but let in the Air, and then let them fall, and the Guinea will be down long before the Feather, which meets with so much more Resistance from the Air.

EXPERIMENT LXI.

Take a tall Glass with a little Water made acid, by a few Drops of *Aqua fortis*, and place it upon the Plate of the Pump, and cover the same with an open Receiver, to which is fitted the last Apparatus, holding a Piece of Chalk ready

ready to let fall; then having exhausted the Air, you carefully thrust down the Wire, to let the Chalk fall into the Fluid below. And since one is an ACID, and the other an ALKALI, a strong FERMENTATION and EFFERVESCECE will ensue, which will soon subside and cease upon letting in the Air.

N. B. Great Care must be taken in making this Sort of Experiments, lest any Mischief happen by too violent a Commotion, Accension, or Explosion, upon a Mixture of such active Bodies.

EXPERIMENT LXII.

Let a tall Receiver (such as is used for the *Guinea and Feather Experiment*) have a Cork fixed and sealed into its upper Orifice, to be perfectly Air-tight; and then put a pointed Wire through the Cork, an Inch or two below it, and secure and fasten that likewise with Wax. This being done, place it upon the Pump, and make as perfect a Vacuum as possible; then take the Chain (or Wire) of the Conductor of an electrical Machine, and hang it to the Wire upon the Top of the exhausted Receiver, and excite the Globe (or Cylinder) by turning the Wheel, and you will have the Pleasure of seeing the Electricity descend from the Wire, and diffuse itself through the Vacuum in the Appearance of *Liquid Fire, or rather luminous Phosphorus*. And this Phænomenon will continue as long as the Vacuum, and the Machine is in Motion. N. B. For this Sort of Experiments, the Room must be very dark.

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EXPERIMENT LXIII.

If the electrical Machine be of the late improved Form, *viz.* such as has the Foot or Stand upon which the Cushion is fixed, made of Glass, then will the Conductor be electrified *negatively*; and the Chain being put upon the Wire in the Cork of the tall Receiver exhausted, you will observe (when the Machine is in Motion) the beautiful Appearance of the electrical Fluid rising from the Bottom of the Receiver to the Top, and going off by the Wire to the Conductor, to supply the electrical Fluid to the Machine, which is now in a negative or *Minus* State.

N. B. For this Experiment the Receiver should be cemented into a Brass Socket at Bottom, with a Stop-cock to screw it on to the Pump to be exhausted, and then to be taken off, and screwed into a large wooden Foot.

N. B. These two Experiments explain the electrical State of the Air wherein the Electricity descends from the Clouds electrified *plus* to the Earth; and on the other Hand, as it rises from the Earth to the Clouds, when they are in the State of *minus* Electricity, or less electrical than the Air near the Earth.

• EXPERIMENT LXIV.

Let Writing with *solid Phosphorus* on blue Paper, be put under the Receiver; as the Air is exhausting, the Letters will be more and more lucid and shining; and the Receiver filled with Fumes. These Phænomena of Phosphorus and Electricity are greatly promoted by a *Vacuum*.

F I N I S.